Perspectives of the Virginia Association of Municipal Wastewater Agencies

Nutrient Criteria Stakeholders Meeting

October 23, 2006

About VAMWA

- 56 local governments & authorities that own and operate municipal wastewater treatment plants.
- Serves >95% of Virginia's sewered population
- Primary Purpose

"...to ensure that Virginia's water quality programs are based on sound science and good public policy...

- *...to protect public health and the environment successfully and cost-effectively."*

What would the *ideal* "effects-based" toxic standard look like?

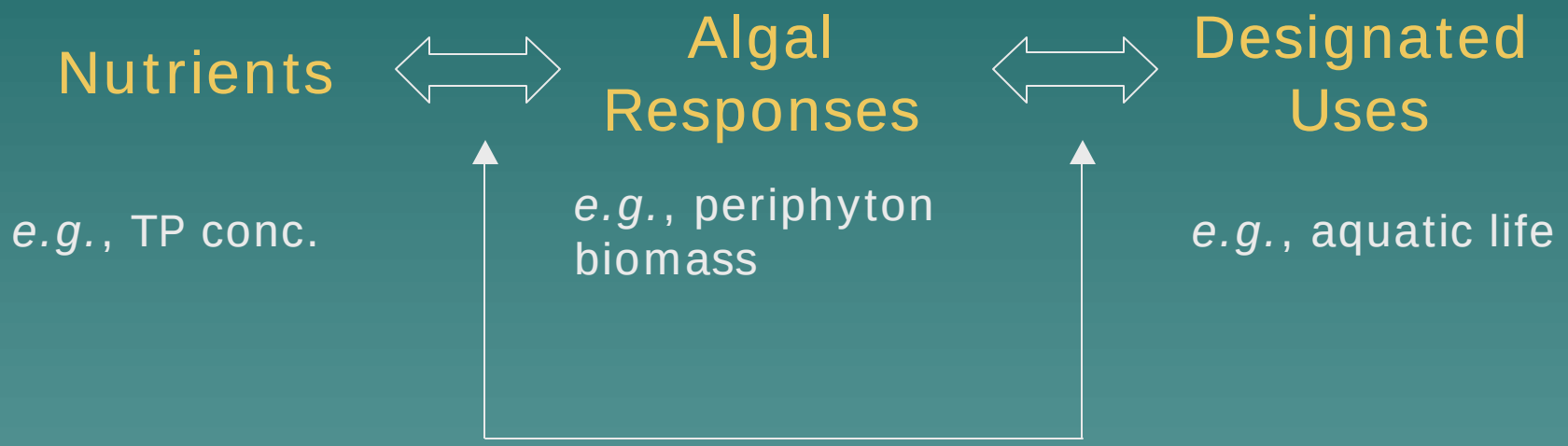
Toxic Parameter

Designated Uses

e.g., copper conc., duration

e.g., aquatic life

What would the *ideal* "effects-based" nutrient standards look like?



Some Realities

- Nutrient concentrations often correlate poorly with in-stream algal responses
- High cross correlation of different stressors
- Limited information on algal responses
- Difficult to link specific algal responses to specific biological effects
  - Benthic macroinvertebrates
  - Fish

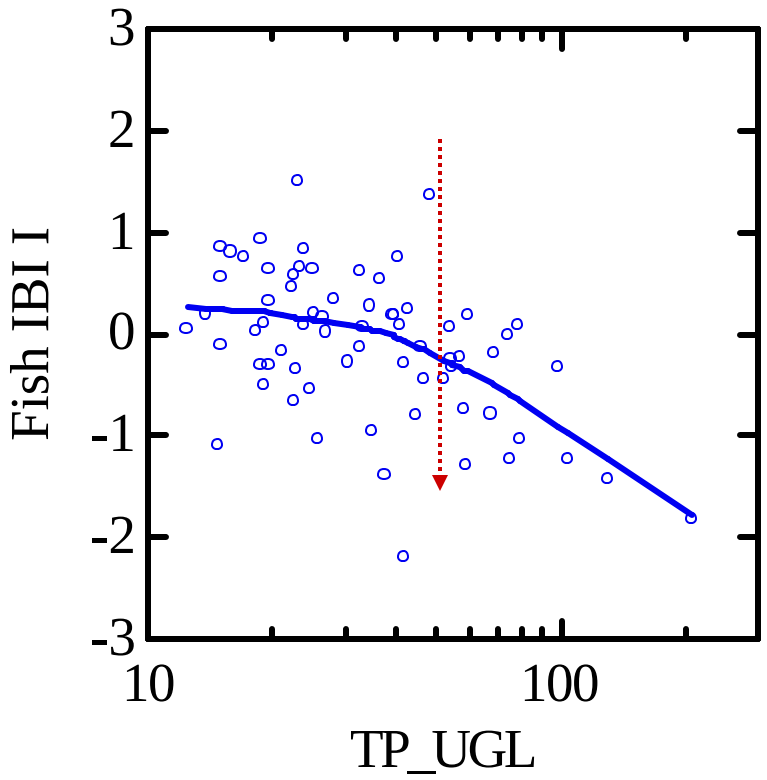
How do we deal with this uncertainty/variability?

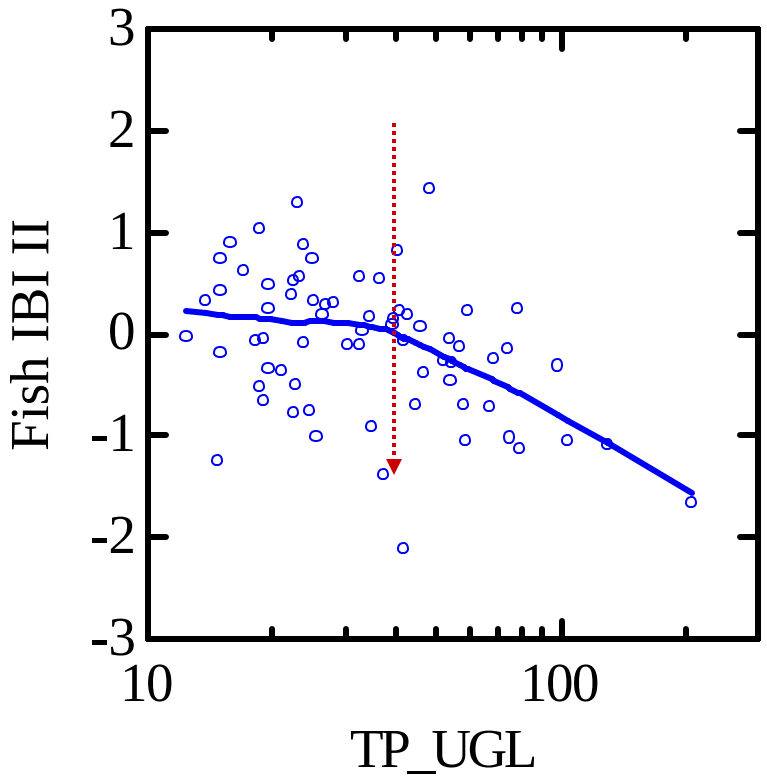
- Effects-based criteria
- Focus on response variables
- Use of translators
- Tiered use designations
- Tiered assessment procedures

Criteria Derivation: Unfavored Approaches

- Percentile-based methods
- Reference condition methods
- Simple bivariate correlations
- Diatom indices

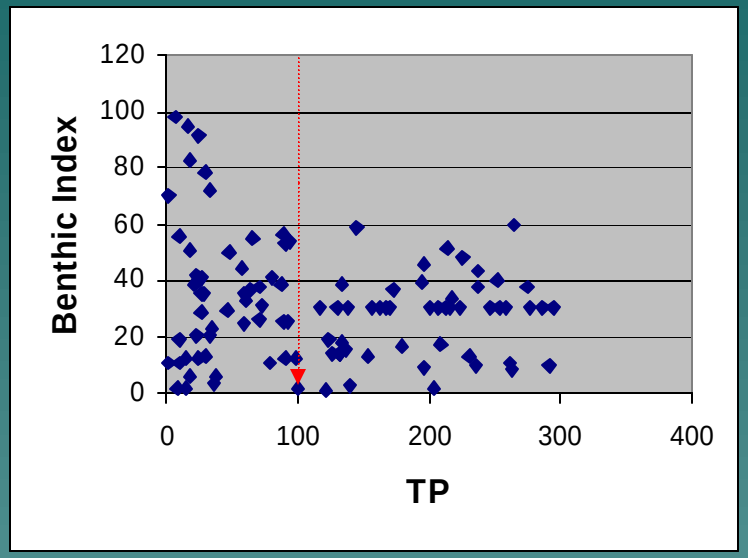
Example of simple bivariate correlations

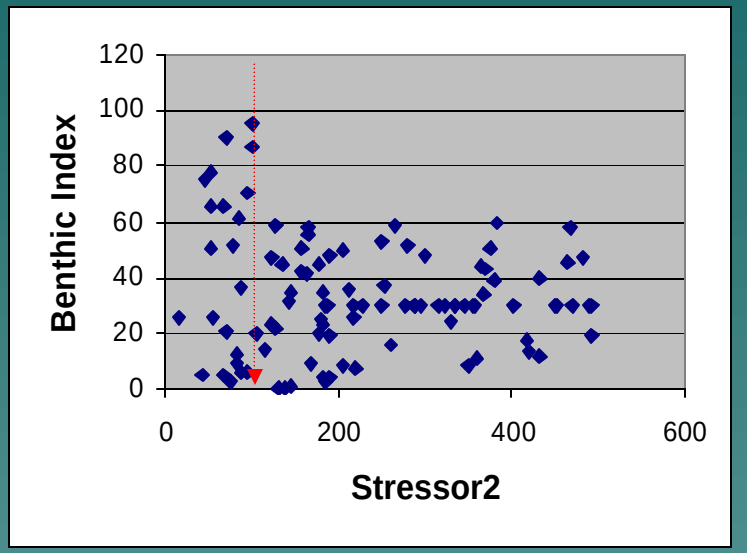


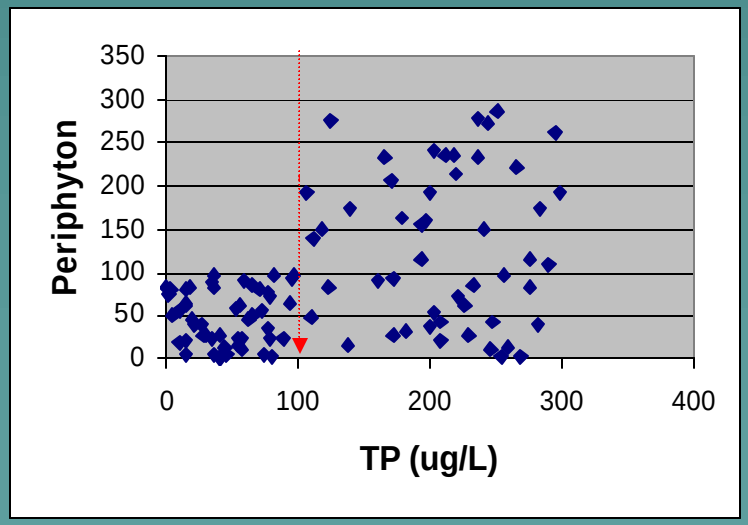


From Stevenson and others (2006)

A randomly-generated example to make the point

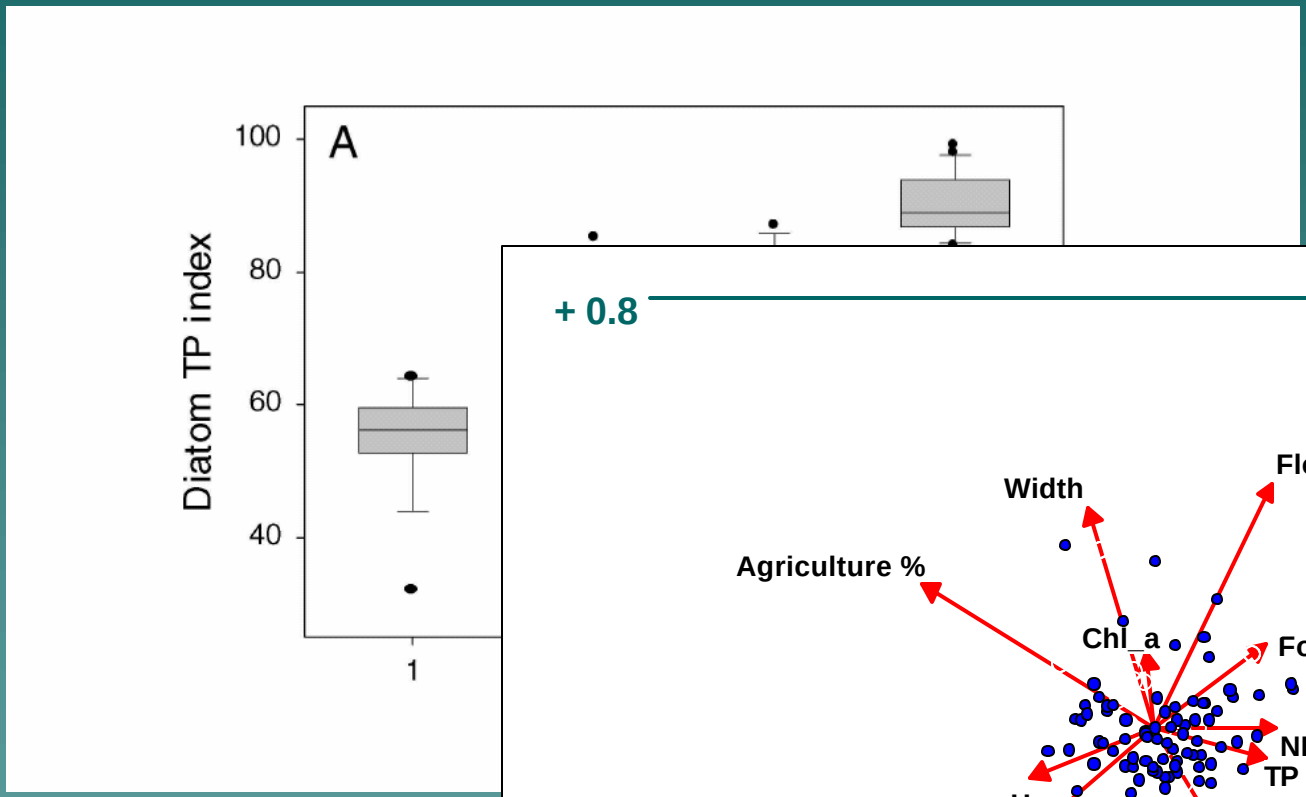


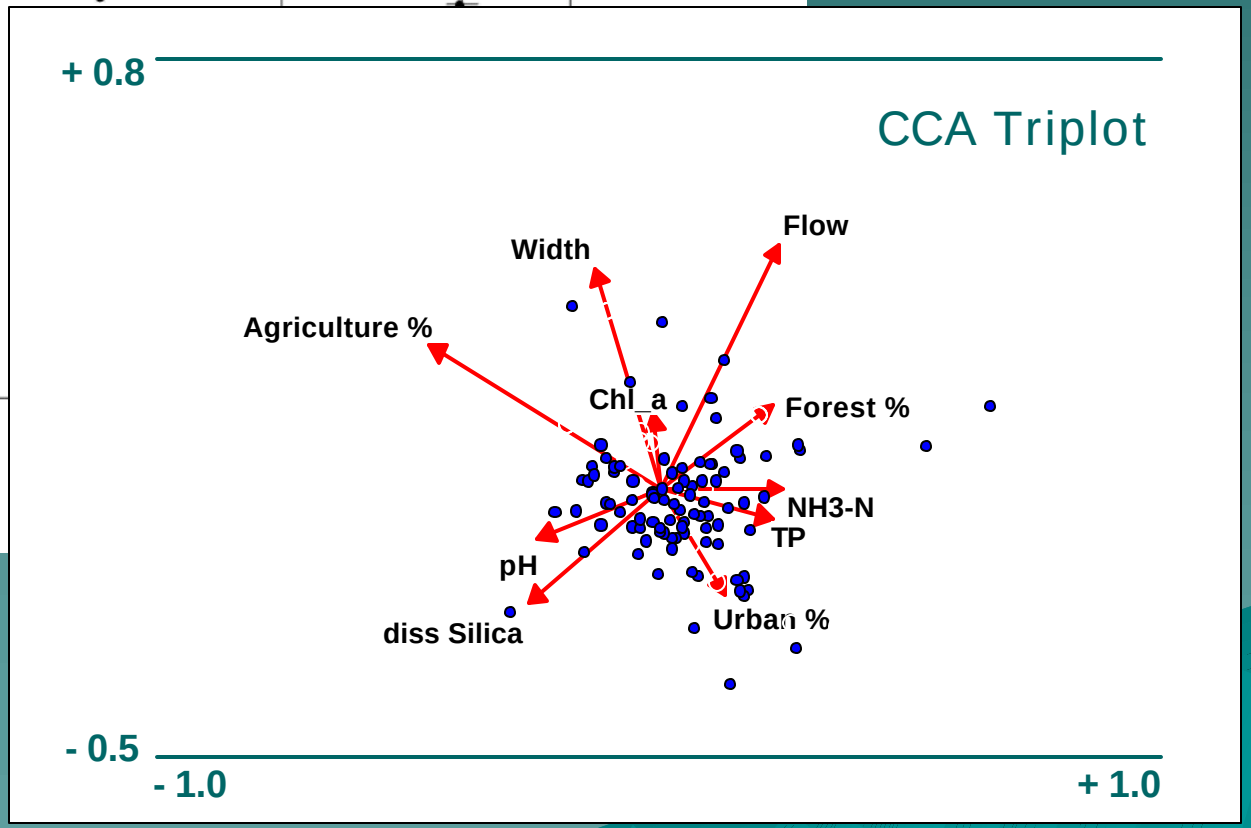




- Stressor2 Threshold for IBI: 100
- Periphyton Threshold for IBI: 150
- TP Threshold on Periphyton: 100

Diatom Indices





From Belton and others (2006)

Criteria Development: Favored Methods

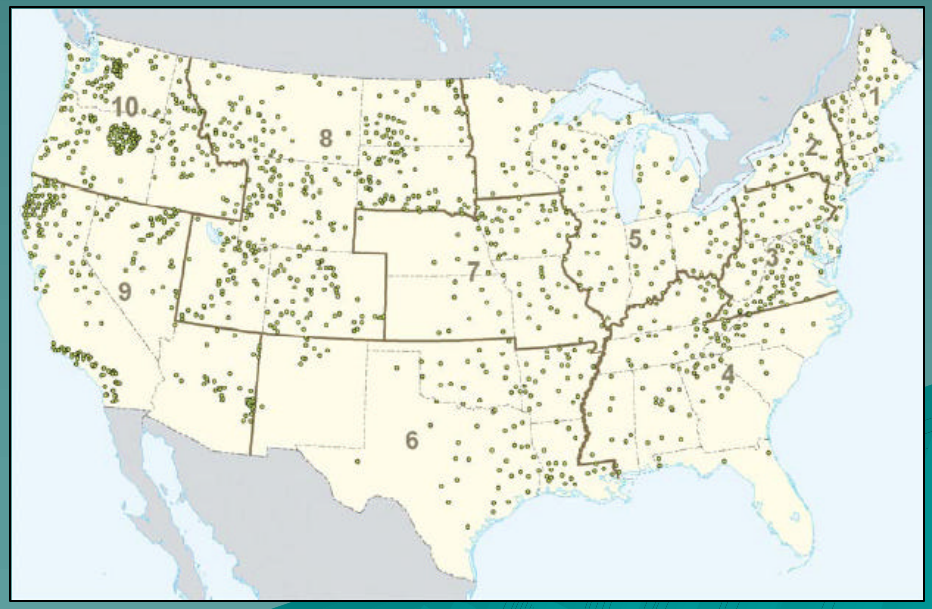
- Multimetric analysis
  - Explore nutrient & periphyton targets
  - Account for other environmental effects
- Mechanistic stressor studies
  - In-stream
  - Mesocosm
  - Modeling

Multimetric Analyses

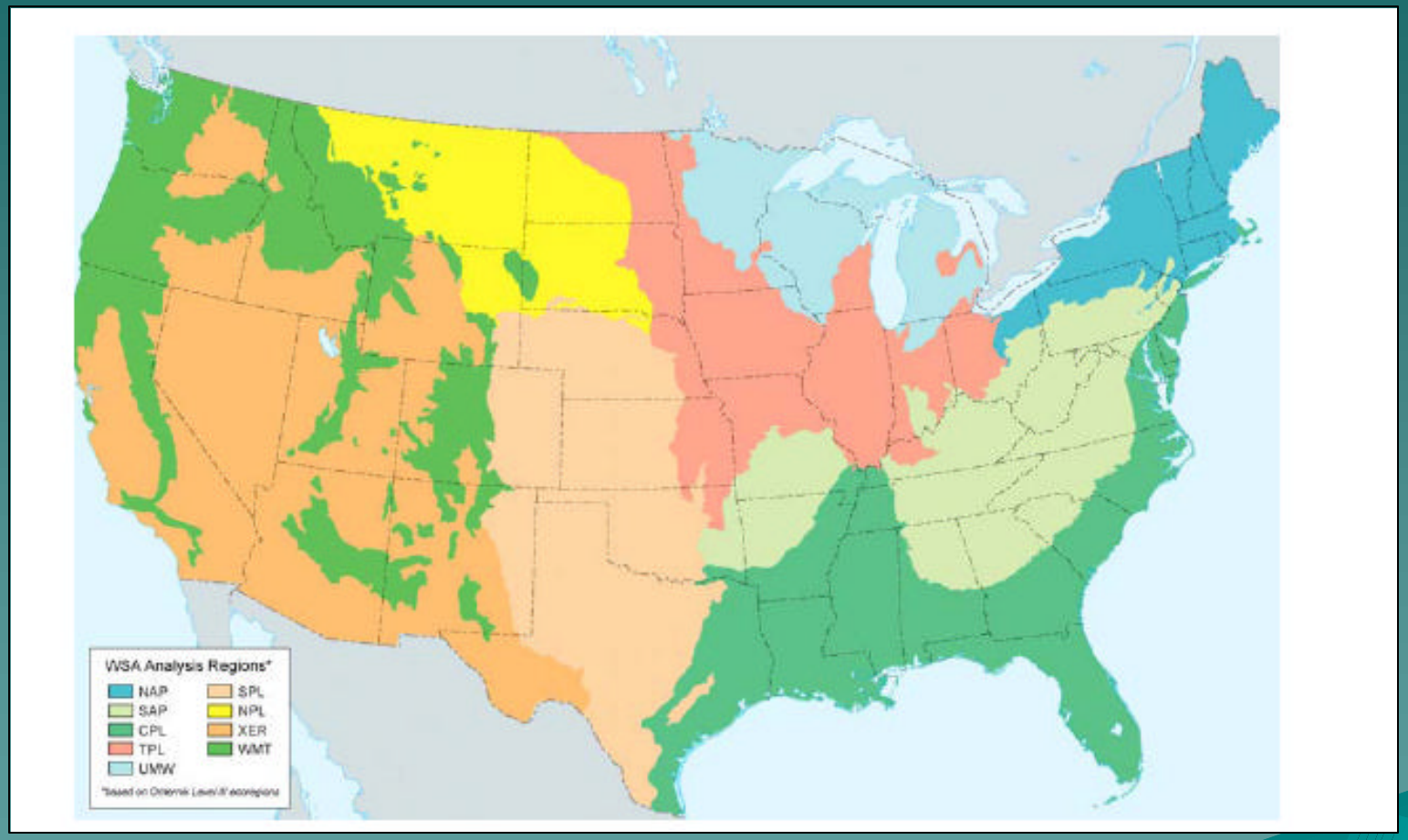
- Where's the golden data set for streams?
  - Nutrients
  - Algal response
  - Habitat
  - Stream characteristics
  - Benthic macroinvertebrate

USEPA Wadable Stream Assessment (WSA)

- Conducted in the contiguous USA 2000-2004
- Data examined on national and ecoregion scales
- 1,392 sites
- Standardized methods for assessing streams
- Identify chemical and physical stressors



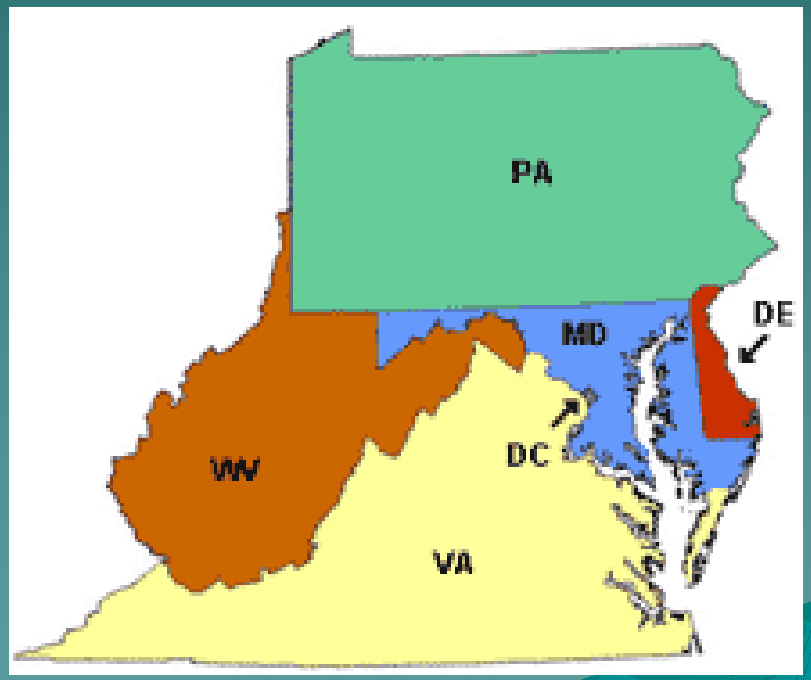
Level III Ecoregions



SAP Region: Southern Appalachians

Data is evaluated at different scales.

- SAP: Southern Appalachians
  - **184** sites monitored
- Region III: Mid-Atlantic
  - VA, WV, MD, PA, DE, District of Columbia
  - **87** sites monitored
- Virginia
  - **40** sites monitored



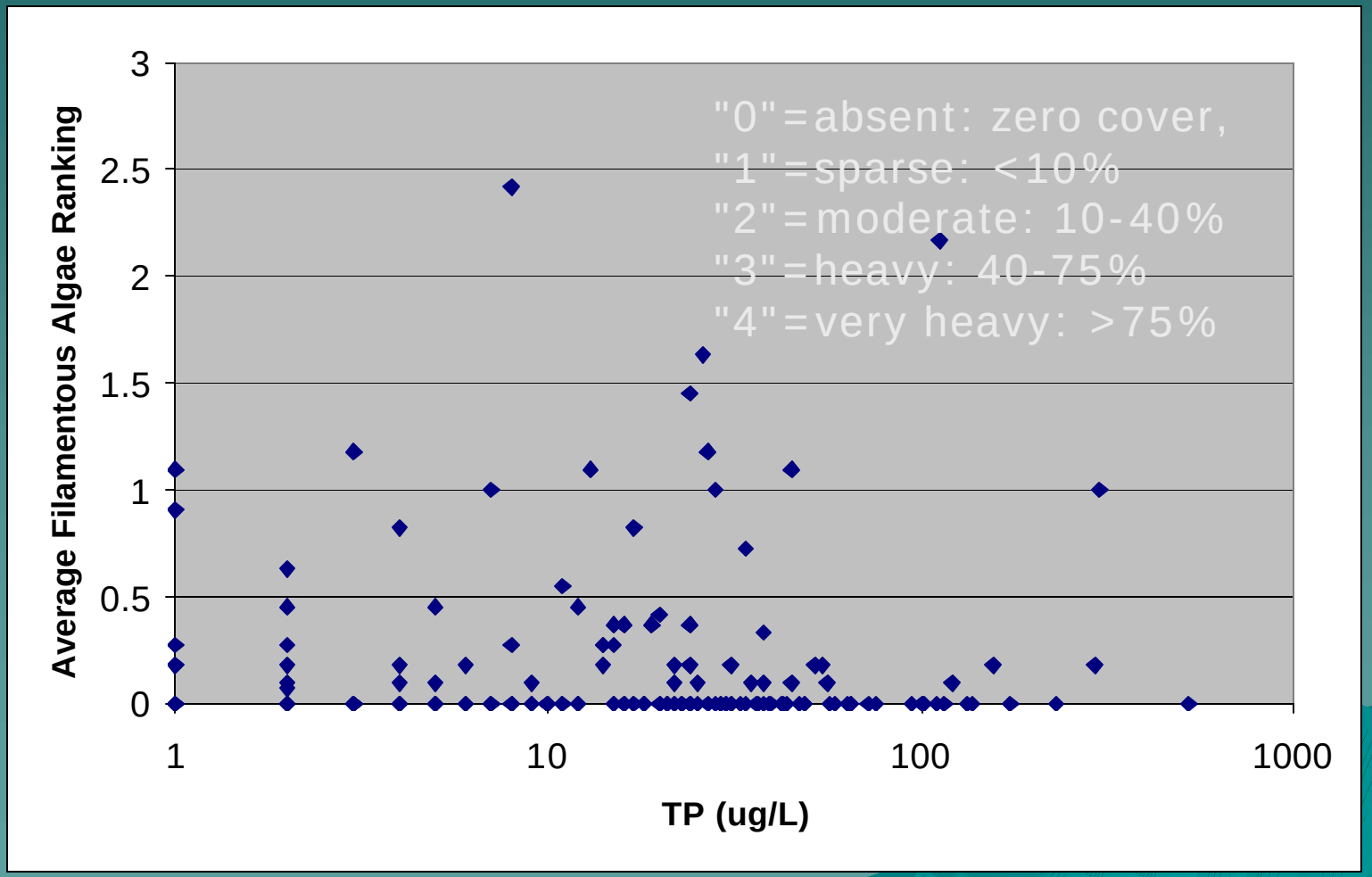
Region III: Mid-Atlantic

Key parameters

- Physical/Biological
  - Riparian Disturbance
  - Fish Cover
  - Woody Vegetative Cover
  - Relative Bed Stability
  - Macroinvertebrate Index
  - Filamentous Algae Ranking
- Chemical Parameters
  - Total Phosphorus
  - Total Nitrogen
  - Conductivity
  - NO_3^-, NH_4^+, SO_4^{2-}, Cl^- , Zn
  - Dissolved Organic Carbon
  - Acid Neutralizing Capacity
  - Turbidity
  - Sum of Base Cations

Photo: VDEQ

Little filamentous algae observed, not correlated to TP or TN

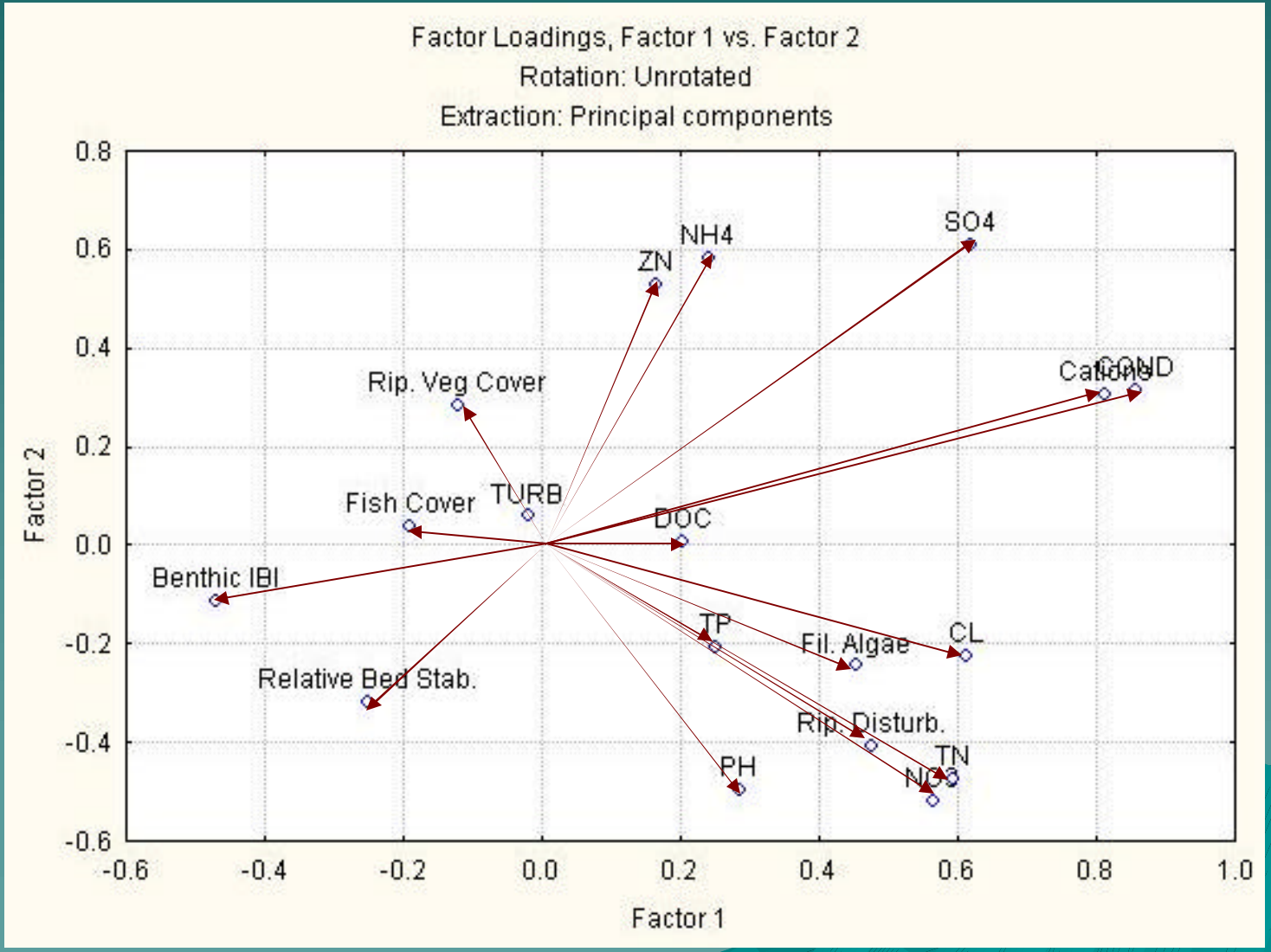


Benthic index correlated to…

(Spearman rho > 0.3 and sig.)

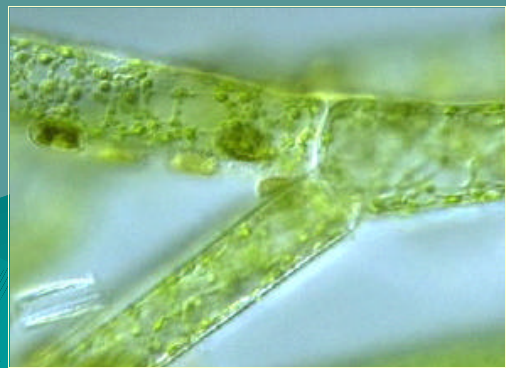
- Ammonia
- Dissolved solids/conductance
- DOC
- Total phosphorus
- Total nitrogen
- Turbidity
- Relative bed stability

Many cross correlations



Criteria Development: Favored Methods (cont.)

- Mechanistic Stressor Studies
  - Diel DO fluctuations
  - Physical impacts
    - Fish spawning
    - Mussel attachment
  - Benthic macroinvertebrate impacts
  - Consider potential of positive impacts
    - Benthic macroinvertebrates
    - Fisheries



What are the relations between periphyton and biota?

Author	Locale	Periphyton Correlation
Stevenson and others (1999)	Streams in MI, KY	Positive with macroin. & fish
USGS (2003)	Streams in PA, WV	Few significant correlations
Various stream ferlization studies	Canada, western US	Increased aquatic insect and fish production
Nordin, 1985; Welch, 1992; Carpenter and others, 1998; Smith and others, 1999	Various streams	Reductions in benthic macroinvertebrate diversity at high algal levels.

Half saturation coefficients (Ks) in literature highly variable.

Taxa	Ks (ug/l P)	Habitat	Reference
Diatoms	0.5 to 7.2	lotic - epilithic	Bothwell (1985)
Cladaphora glomerata	15 to 86	lotic - epilithic	Lohman and Priscu (1992)
Cladaphora glomerata	31	lentic - epilithic	Rosemarin (1982)
Stigeoclonium tenue	93	lentic - epilithic	Rosemarin (1982)
Cladaphora glomerata	30 to 250	lentic - epilithic	Auer and Canale (1982)
Complex Assemblage - bacteria, bluegreens, diatoms, green algae	263	lentic - epiphytic	Scinto and Reddy (2003)
	499	lentic - metaphyton	
	508	lentic - epipelon	
Cyclotella meneghinianna	24.8	lentic - pelagic	Tillman (1977)
Asterionella formosa	86.7	lentic - pelagic	

Table courtesy Bill Brown, Pa DEP

Modeling of Diel DO Fluctuations

$$\Delta_c = \frac{p_a}{\left[\frac{0.5K_a[1-\exp(-K_a t]}{[1-\exp(-0.5K_a t)]^2}\right]}$$

Diel DO range as function of primary production and reaeration rates (DiToro, 1981)

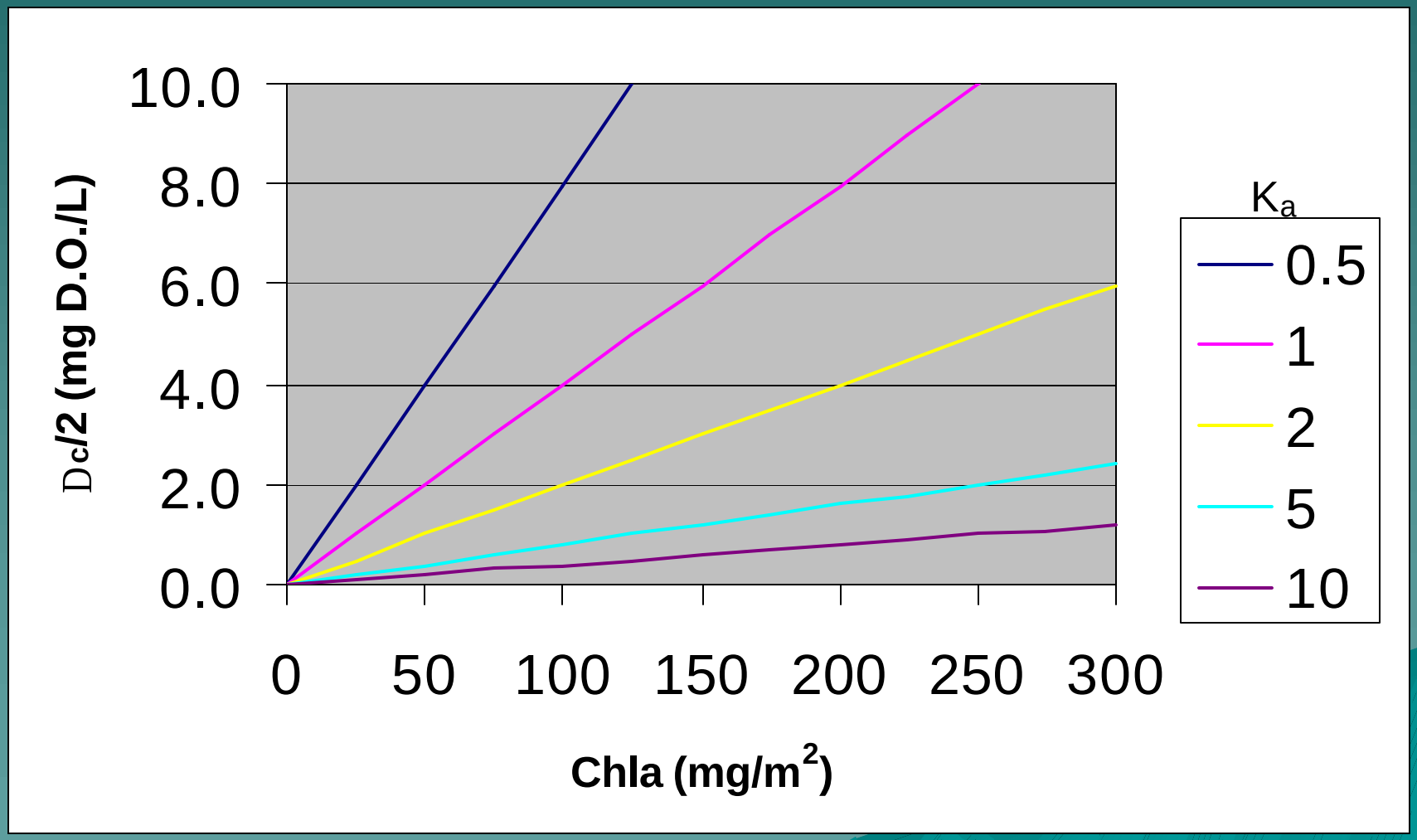
$$p_a = [a_{op} G_{\max} (1.066)^{T-20} P] G(I_a)$$

Primary production as function of growth rate and biomass. (Thomann and Mueller, 1987)

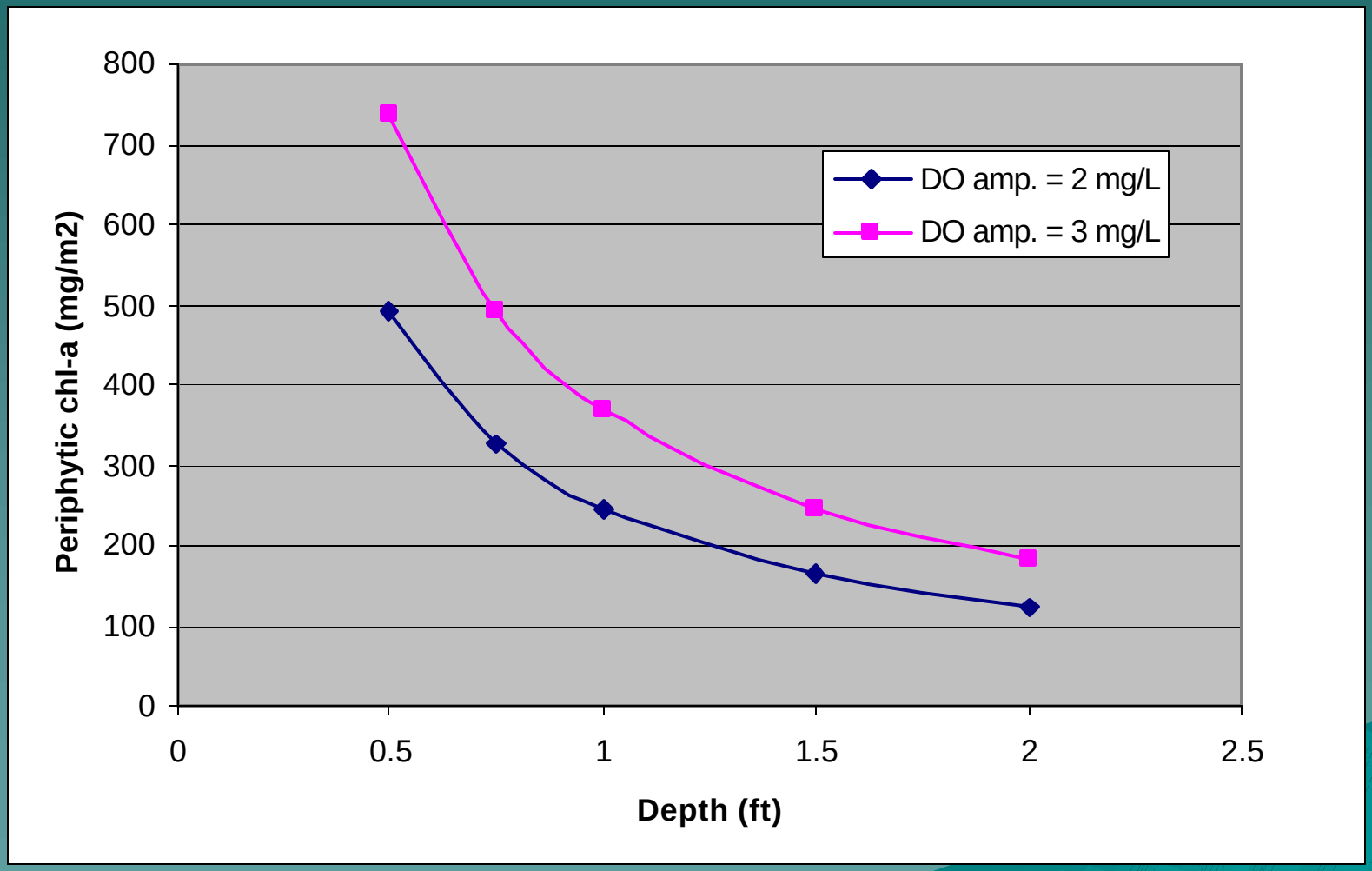
$$K_{al} = \frac{12.9U^{1/2}}{H^{3/2}}$$

Reaeration as a function of depth and velocity. (O'Connor & Dobbins, 1958)

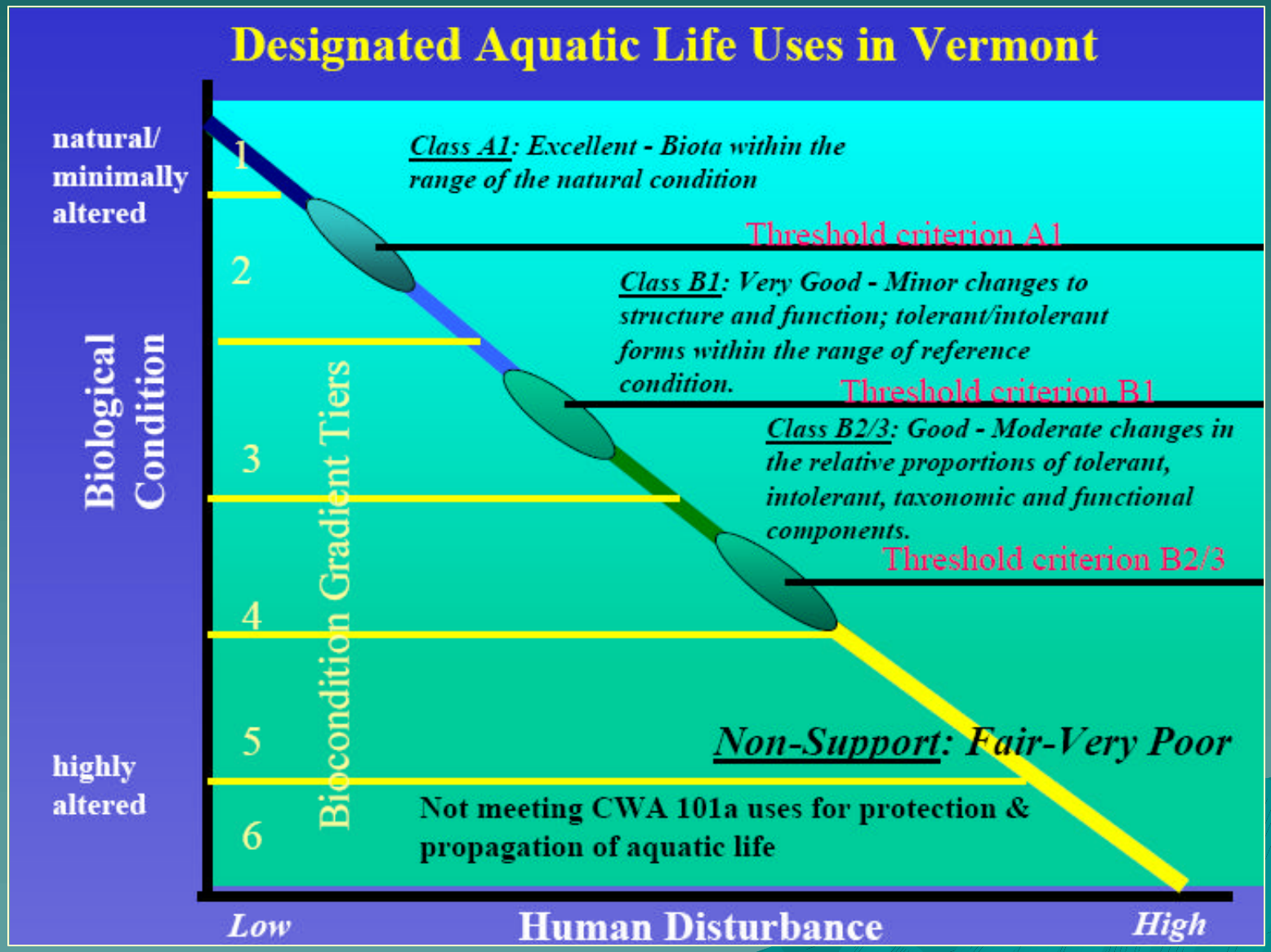
Chlorophyll targets sensitive to depth and velocity



Baseflow= 11.5 cfs, Width = 20 ft



Tiered Aquatic Life Uses



From Burnham, 2003 (Vermont DEC)

Concept of Tiered Uses with Nutrient Criteria

- Tier “A”
  - Exceptional or undisturbed watersheds
  - Low potential for algal biomass accrual
- Tier “B”
  - Mixed land use watersheds
  - Higher nutrient concentrations
  - Potential for algal biomass accrual under favorable conditions
- Tier “C”
  - Highly developed watersheds or effluent-dependent segments.
  - Higher potential for algal biomass accrual under favorable conditions

Tiered Assessment Procedure

- VAMWA endorses the tiered assessment concept as presented by the AAC (2006)
- Considered critical to addressing uncertainty/variability in the nutrient-designated use linkages.
- What about permitting…

Will we be forced into inflexible pass-fail nutrient criteria?

From USEPA Guidance Memo (Nov 14, 2001):

A state…could establish numeric criteria for response variables such as dissolved oxygen, chlorophyll-*a*, and a measure of water clarity and also adopt a procedure to quantitatively address causal parameters (i.e., nitrogen and phosphorus) and determine nutrient loads in specific water body segments that will achieve the response variable criteria…This translator procedure, together with numeric criteria for response variables, would provide a state…with the means to set targets for permit limits, assessment, and total maximum daily loads.

Example, Pa DEP – Skippack Creek

- Heavily impacted stream
- Set periphyton target of 100 mg/m2
- Used Dodds *et. al.* (2002) empirical model to identify instream TP target of 0.240 mg/L

from Carrick (2006)

$$\log Chl = \log(TN)0.236 + \log(TP)0.443$$

Nutrient Targets

- Set
- More conservative?

- Based on response
- Tiered to use
- Allowance for segment -specific considerations

Analogous to WLA for BOD, NH3

Recommendations for Downstream Loading Effects

- Keep established loading goals as loads.
  - Don’t attempt to convert to flow-variable concentration criteria.
- Utilize the TMDL process to set loads for impaired waters.
- Don’t tinker with tidal standards.

Summary: Elements of Workable Standards

- Effects-based criteria
  - Focus on response variables
  - Allow translators
- Better data sets needed
  - Algal responses
- Tiered uses
- Tiered assessment procedure
- Keep loads as loads